3

Some Aspects of the Comparative Biology of Parrot Fishes at Bermuda[1]

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(Plate I)

INTRODUCTION

ALTHOUGH parrot fishes are a conspicuous element of the coral reef environment, their biology is poorly known, with little available on their behavior and ecology. This paper presents data bearing on the species problem in Atlantic parrot fishes, as well as information on algae on the teeth of certain members of this group, social organization, home caves, the mucous fold, reproductive season, spawning and eggs. Most of the observations were made during the summer of 1956 at Bermuda, and a few were obtained at Bimini, Bahamas, by the first author and at Puerto Rico by the second author.

It was demonstrated only recently that parrot fishes are markedly sexually dimorphic (Winn & Bardach, 1957). All of the species studied showed a marked decrease in respiration when they were resting and some species are then covered by a mucous envelope (Winn, 1955). Winn & Bardach (1959) have presented evidence suggesting that one of the functions of the mucous envelope lies in the reduction of predation.

It is with sincere appreciation that we acknowledge the cooperation of Dr. William Sutcliffe and the employees at the Bermuda Biological Station. Mr. Brunell Spurling of the Station made the original observations on home cave behavior of one species of parrot fish.

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GENERA, SPECIES AND SEXUAL DICHROMATISM

In a brief paper, Winn & Bardach (1957) summarized the synonymies of the species of Bermuda parrot fishes, based on different sexes. Since then Schultz (1958) has published a broad review of the parrot fishes of the world. This serves as an excellent basis for a consideration and clarification of parrot fish speciation and biology. Some unrecognizable names can be discarded and others properly placed. We follow Schultz's names with the exception of some noted later.

The only genera of parrot fishes found in the West Indies are *Scarus, Sparisoma, Cryptotomus* and *Nicholsina.* Several characters may distinguish *Sparisoma* from *Scarus* in addition to those mentioned by Schultz (1958). The eggs of *Scarus* have a modified fusiform shape and those of *Sparisoma* are nearly spherical (Plate I). Species of *Sparisoma* are found in loosely knit aggregations whereas species of *Scarus* tend to form schools and more highly organized aggregations. Goodrich & Hedenburg (1941) demonstrated that *Sparisoma* has disc-shaped chromatophores and *Scarus* has branched chromatophores. Whether or not all of the above traits will remain as generic distinctions awaits the investigation of all species.

Our synonymies of *Scarus croicensis* (*croicensis,* the female and *taeniopterus-punctulatus,* the male) and *S. vetula* (*vetula,* the male and *gnathodus,* the female) were based upon behavior, sex and the effect of testosterone injec-

tions (Winn & Bardach, 1957). More than 50 individuals of *S. croicensis* in the female color pattern proved to be females, and more than 20 in the male color pattern proved to be males. Four individuals, at about the size when they transform into mature adults (90 to 130 mm. in total length), were found to be males with the female color pattern. Thirty-three functional females of *S. vetula* were in the female color phase, and 31 functional males had the male color pattern. Three individuals were mature males in the female color phase with two of them near the transformation size. It thus appears that females and immature males have a similar color pattern and that males assume the more polychrome pattern at a certain stage of maturity, presumably correlated with higher testosterone levels. We also found that *Sparisoma distinctum,* the female, was a synonym of *aurofrenatum,* the male, on the basis of sex and observations of their spawning together.

At the time we also concluded that *Sparisoma abildgaairdi,* the female, was a synonym of *viridis,* the male. Schultz (1958) apparently did not accept this conclusion and kept the names separate. Our conclusion was based on the following evidence: (1) all *viridis* examined were males and all *abildgaairdi* were females; (2) only immature stages of the *abildgaairdi* red color phase and only large mature *viridis* males in their bright green phase were observed; (3) during the breeding season individuals of both color phases were usually seen together in loose aggregations and *viridis* frequently chased individuals of *abildgaairdi* but not other parrot fishes; and (4) Longley & Hildebrand (1941) noted that *viridis* has a spotted color phase similar to that of *abildgaairdi.* We are now able to present two more indications that these phases are the sexual forms of one species. These are: five *abildgaairdi* females implanted with testosterone at the Marine Laboratory of the University of Puerto Rico became greenish with a yellowish opercular spot, orange around the mouth and developed the tail pattern characteristic of the *viridis* male; and several individuals observed were intermediate in color between *viridis* and *abildgaairdi.* The only problem that remains slightly puzzling is the presence of ripe females at Bermuda during June, July and August, at a time when the males' testes were not as large as would be expected from the comparison with other fishes. They were, however, enlarged and mature.

Under the name *Sparisoma chrysopterum,* Schultz (1958) synonymized such forms as *squalidus* and *brachialis* without mention of the sexes involved. The form *brachiale* of Beebe & Tee-Van (1933) is the adult male with an overall light blue color and rose-orange fins, while the *squalidus* form, which is mottled grayish with reddish-brown blotches along the side, is the female. Injections of testosterone into individuals of the *squalidus* form caused them to turn bluish like *brachiale.*

One specimen was caught at Bermuda that was a ripe male and referable to *Sparisoma axillaris,* previously not recorded from Bermuda. Practically nothing is known about this species (Schultz, 1958).

The Mucous Envelope

Since Winn (1955) originally described parrot fishes covered with large and conspicuous mucous folds around their bodies at night, it has been possible to expand and verify most of these observations, which were made at Bimini during the summer of 1954.

Scarus croicensis and *punctulatus,* which have since been synonymized (Winn & Bardach, 1957) were originally observed to form a mucous fold. Subsequently laboratory observations confirm the fact that this species forms the fold at night during other seasons and places (February and March, 1955, at Bimini, and summer, 1956, at Bermuda). Individuals observed ranged from 1.5 cm. to 34 cm. in total length.

It was not possible to verify the fact that *Scarus* (*Pseudoscarus*) *guacamaia* regularly produced a mucous fold. More than 50 specimens, ranging from several inches to two feet in length, failed to form a mucous fold at night at Bimini in February and March, 1955, and at Bermuda in the summer of 1956. However, these fish did produce a heavy secretion of mucous on handling and when operated on for other purposes, and during the summer of 1959 two small individuals produced the fold for at least 48 hours both in dark and in light. One specimen with blue teeth was observed continuously for a week and intermittently over a longer period (Winn, 1955). Black-and-white and color photographic records were obtained of this specimen in its mucous fold so that there can be no question as to the validity of the observation. No other species of parrot fish in the western North Atlantic has blue teeth except a form referred to as *Scarus coelestinus.* It is not definitely known, however, whether this is a valid species or merely a color phase of *S. guacamaia.* Whether or not the original observation of envelope formation, made at Bimini, was the result of an abnormal situation or a confusion of species is unknown. It is possible that the abnormal environment of aquaria and concrete tanks prevents this species, but not others, from secreting a normal fold.

Underwater night observations would probably be the best way to solve this problem. Individuals of *Scarus croicensis* were observed to produce the fold normally in their natural habitat (Winn, 1955).

Both male and female *Scarus vetula* produced mucous folds in tanks at Bermuda, but with some irregularity. Blinded individuals frequently formed them during the day. It is possible that this irregularity resulted from the relatively abnormal environment of aquaria or that the mucous secretion is not quite as well developed as in *S. croicensis.* More than 50 females, placed in glass and concrete tanks, exhibited an "alarm" or spotted color phase at all times which was not the normal field pattern. Several individuals placed in a very large glass and concrete display tank in the Bermuda Aquarium at the Flatts, Bermuda, immediately took on the usual striped daytime color phase. *Scarus coeruleus* did not secrete a fold at Bimini.

Species of the genus *Sparisoma* do not secrete a mucous envelope. Many individuals of the following species have been observed both at Bimini and Bermuda: *Sparisoma aurofrenatum, viridis, chrysopterum* and *radians.* The observation of one individual of a species tentatively identified as *S. pachycephalum* (actually *S. rubripinne,* see Schultz, 1958) which supposedly secreted a mucous fold under anoxic conditions in company with three individuals of *Scarus croicensis* (Winn, 1955) must now be considered either as an anomaly or a mistaken observation. We did not recheck this species at Bermuda.

Injections of a large number of substances produced negative or conflicting results. At Bimini, injections of atropine, pilocarpine, adrenalin and acetylcholine with eserine first appeared to produce the desired antagonistic effects, but completely negative results were obtained after repeated injections at Bermuda under similar temperatures and reproductive condition. The other materials injected were: sea water, distilled water, physiological saline solution, ammonium chloride solution, eserine salt, melanophore-stimulating hormone and hydroxy-tryptamine. Placement of fish into water of reduced salinity also gave no definitive results.

Although the effects of standard physiological preparations were equivocal, secretion of the envelope at night and under stress suggests that the process may be associated with a lowered peripheral circulation and therefore a lowered oxygen supply to the mucous-secreting cells. Both reduced metabolism during "sleep" and adrenaline-governed metabolism during stress could evoke such circulatory adjustments. This suggestion needs to be checked by experiments.

Algae on Teeth

Conspicuous growths of algae were present on the teeth of some large specimens of *Scarus guacamaia* and *S. vetula.* These were usually more abundant at the corners of the mouth. Such obvious growths were not observed in the other species of parrot fishes. Dr. Randolph Taylor of the University of Michigan identified the species of algae involved as *Cladophora* sp., *Ectocarpus* sp. and an unidentified miscroscopic alga.

There is a distinct possibility that the *Ectocarpus,* which made up the bulk of the growth, is the same as that found on sea turtles. Isokawa (1956) reported the presence of an unidentified species of *Ectocarpales* growing on the surface of the teeth of two Pacific parrot fishes, *Callyodon ovifrons* and *Calotomus japonicus.* He demonstrated that the alga grew on the surface, into the dentine and into the surrounding tissues.

Social Organization and Home Caves

A series of qualitative observations was made on the social organization of parrot fishes. Patterns of social behavior varied between genera and within genera to some degree.

The sparisomids seemed to maintain themselves in loose aggregations and even individually at times. There was no apparent discrete organization that could be discerned from observation. The green males of *Sparisoma viridis* were frequently observed chasing the presumed red females (formerly *S. abildgaairdi*) but rarely other fishes. This was also true of the other species of sparisomids.

The scarid parrot fishes aggregated (or schooled) together with a much closer relation between individuals that varied somewhat among species. Individuals of *Scarus guacamaia* moved in large schools for feeding purposes. They frequently could be seen close to shore with their backs out of water during feeding. These groups of mature individuals consisted mostly of large females (24 inches total length and larger) and smaller males. In a very general way, they aggregated according to size, and presumably age categories, *viz.,* approximately 1.5 to 3 inches (total length), 6 to 14 inches, 14 to 20 inches, and 24 inches or larger, during the summer. In Castle Harbor, Bermuda, three of the four size groups, all of them consisting of fish that were not mature, were seen commonly. The larger, mature group was primarily observed on the outer beaches.

Scarus croicensis maintains itself in large schools of usually 5 to 40 individuals, although smaller or larger numbers may be more rarely involved. These schools are distributed into size groups as in *S. guacamaia.* There are four primary size groups, in August, as follows. The young of less than 1 inch have then made their first appearance and comprise one of them. Another size group of fish primarily 2 to 3 inches long aggregated, as did fish about 4 to 8 inches and fish 10 to 14 inches long. Sizes varied somewhat from place to place, which may be an indication of either differential growth or differential time of hatching. Maturity was reached variably in the 3- to 4-inch long individuals. The smallest of the matured fish were females. The group of 4 to 8 inches usually consisted of females with one or two bright males. In 13 instances, an observed group was comprised of one male and 10 to 15 females, once one male and three females, four times two males and 10 to 15 females, and once three males and 20 females. In two cases of groups containing fish 10 to 14 inches long, there was one male and two females. These largest individuals were seen only rarely on the outer reefs and then only singly or in groups of two or three—a possible indication of their relative scarceness.

Scarus vetula occurred in aggregations of one male and usually two, three or four females that stayed together, at least during several hours of observation. The data are as follows: one male and two females were observed 11 times; one male and three females were seen three times, and one male and four females were seen nine times. The fish did not actively swim together in a school as did *S. croicensis.* They would stay together in one general area, grazing along the bottom, and might be separated by as much as approximately 15 yards. Intrusions by individuals of the same species from other groups were rare, but when this happened a chase ensued. Once, a large male chased two other males and one female from the region of a coral head. In another instance, a male impaled on the end of a spear was followed by three females 15 to 22 yards to the edge of the boat. Another time, one male approached another male with two females, and the latter male chased or trailed the intruder at a distance of about 20 feet for more than 300 feet. Bardach noted that there was no apparent association between the non-breeding males and females in Puerto Rico early in December, 1956. On the outer beaches of Bermuda, a large male would occasionally travel in the feeding aggregations of *S. guacamaia* and would escape or go to a home cave with them.

The aggregations of the parrot fishes (*Scarus vetula* and *S. croicensis*) may be compared to that of the cow-bull organization of some mammalian groups where a male leads a group of females in a herd. In the case of parrot fishes, there frequently seems to be a "suppressed" male with the female color pattern, especially in the aggregations of *S. croicensis* and rarely in those of *S. vetula.* There seems little doubt that these analogies in social organization represent similar methods in solving spatial problems of reproduction among browsers which move continuously.

A phenomenon of home caves occurs in *S. guacamaia.* This was discovered by Brunell Spurling of the Bermuda Biological Station when he was faced with the problem of catching this species. Individuals move out from certain ledges or caves under the rocks, either along the shoreline or in deeper water, to feed during the day. Any disturbance causes them to swim rapidly, in an escape reaction, directly to the cave where they stay at night and when not feeding. Mr. Spurling placed his seine between the feeding area in the turtle grass beds of Castle Harbor and the caves along the shoreline. The fish which were feeding on these beds were then disturbed and they swam directly into the net in front of the cave holes. That this was a nonadaptable reaction was shown by the fact that they "kept trying to swim through the net," and when the seine was lifted like a gill-net, they usually did not attempt to swim in any other direction. A similar situation existed on the outer beaches except that the caves were usually in deeper water. This homing behavior was not found in any of the other parrot fishes commonly observed, although it could have occurred under situations not readily observable.

The escape behavior of *Sparisoma radians* was interesting in that the fish sometimes swam away long distances, but frequently dashed a short distance and then stopped by a clump of algae or other plants. In this position they were difficult to see because of their spotted and striped alarm color pattern which blended into the background.

Reproduction and Eggs

All of the species observed in detail at Bermuda spawned during the months of June, July and August (*Scarus croicensis, S. guacamaia, S. vetula, Sparisoma chrysopterum, S. viridis, S. aurofrenatum* and *S. radians*). At least some of the males had running milt and most of the females contained ripe or ovulated eggs. Adults of *S. croicensis* were ripe in February and March of 1955 at 21° to 25°C. and not ripe during June, July and August of 1954 at Bimini, Ba-

hamas. In December at Puerto Rico, *S. vetula* was not in a breeding condition and a few females of *S. croicensis* were just becoming ripe. Donald Erdman stated that he has collected ripe eggs from *S. radians* in November at Puerto Rico.

Immature individuals of *Scarus croicensis* became mature as males between 110 to 130 mm. standard length and as females between 90 to 100 mm. Individuals of *Scarus vetula* became mature as males at about 210 to 245 mm. and as females around 210 to 220 mm., whereas those of *Sparisoma viridis* became mature males at 160 to 200 mm. and the female matured at 163 mm. In most instances these data are based on 5 to 10 individuals.

On September 5 near North Rock, *Sparisoma aurofrenatum* was observed spawning. The males moved rapidly over a large area but always remained in the same general region. They occasionally stopped to nip at plants and coral. Two males erected all their fins in a display near each other. Sometimes when a male approached another, one was chased away. One female came up a few feet off the bottom when a male was near her. Both then continued going towards the surface as they rotated around and close to each other. This rapid movement to the surface by a female and a male while rapidly rotating was observed twice more. In the latter two instances, a white cloud came out from the pair near the surface. A hand plankton net was swept throughout the area where the white cloud appeared within two minutes of its occurrence. Many eggs of *S. aurofrenatum* were collected in the net. In general, the females, singly or in groups up to six, fed on the algae while staying close to the bottom, whereas the males cruised singly over a wide area containing a few to many females. Several other times a female swam two to three feet off the bottom, where she stayed until a male joined her. They then moved rapidly to the surface, tail down, in a gyrating motion. Males were observed to display at each other several other times when two came together.

From the observations on *S. aurofrenatum,* it is clear that parrot fishes deposit pelagic eggs. Although actual spawning was not seen in the other species, their behavior during the spawning season seemed to indicate that they had similar habits. The ripe eggs of *S. croicensis* measured from 2.4 to 2.6 mm. in length (10 eggs) and were transparent with a yellow oil globule (Plate I); those of *S. guacamaia* were 2.9 to 3.1 mm. and transparent; those of *S. vetula* were 2.8 to 2.9 mm. and transparent with a whitish oil globule; those of *S. aurofrenatum* were 0.9 to 1.1 mm. and transparent with a yellow oil globule; those of *S. chrysopterum* measured 0.6 to 0.7 mm. and were transparent with a yellow oil globule; and those of *S. viridis* were transparent with an orange oil globule. Other slight differences between the eggs were noted but not with enough regularity to consider them as characteristic. As shown in Plate I, all the eggs of the *Scarus* species were of a modified fusiform shape while all the eggs of the *Sparisoma* species were nearly spherical.

Summary

Differences in egg shape, chromatophores and social organization are given as generic characters of *Sparisoma* and *Scarus*. Various species of parrot fishes are discussed in relation to sexual dichromatism. Reasons are given for considering *S. abildgaairdi,* the female, as a synonym of *S. viridis,* the male.

The formation of a mucous envelope is discussed and clarification and verification of the species that produce it is considered.

The data are given concerning the growth of algae on the teeth of *Scarus guacamaia* and *S. vetula.*

The social organization of the various species of parrot fishes is described. It varies from a loose type of aggregation in the species of *Sparisoma* to a more definitive school-like and "cowbull" organization in the species of *Scarus. Scarus guacamaia* lives in home caves where it stays at night and during the day when not feeding. In an escape reaction, the fish returned to their caves according to a set pattern.

Information is given on the reproductive seasons. All common species of parrot fish in Bermuda breed during the summer. The reproductive habits of *S. aurofrenatum* are described in which a male and female gyrate upwards to spawn near the water surface. Descriptions of the eggs of several parrot fishes are given.

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Explanation of the Plate

Eggs of some parrot fishes.

Fig. 1. **A.** *Scarus guacamaia.* **B.** *Scarus vetula.* **C.** *Scarus croicensis.*

Fig. 2. **A.** *Sparisoma aurofrenatum.* **B.** *Sparisoma viridis.* **C.** *Sparisoma chrysopterum.*